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(54) **DISPLAY DEVICE USING MICROPILLARS AND METHOD THEREFOR**

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G02B 26/02	(2006.01)
F21V 8/00	(2006.01)
G02B 27/00	(2006.01)

(52) **U.S. Cl.**

CPC ***G02F 1/1335*** (2013.01); ***G02B 26/02*** (2013.01); ***G02B 6/0008*** (2013.01); ***G02B 6/0078*** (2013.01); ***G02B 27/0018*** (2013.01)

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USPC 349/61, 96, 106; 362/31, 23

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,651,343	A	3/1987	Laor	
6,585,442	B2	7/2003	Brei et al.	
7,884,530	B2	2/2011	Aizenberg et al.	
2002/0186956	A1 *	12/2002	Lowry	385/147
2004/0122328	A1	6/2004	Wang et al.	
2007/0279367	A1 *	12/2007	Kitai	345/102
2010/0053727	A1 *	3/2010	Lee et al.	359/295
2012/0168233	A1	7/2012	Clark	
2012/0314445	A1	12/2012	Masuda	
2013/0172671	A1	7/2013	Rentschler et al.	
2014/0246321	A1 *	9/2014	Tsukada et al.	204/601

FOREIGN PATENT DOCUMENTS

EP	2177558	A1 *	4/2010	C08J 7/12
WO	2014078507	A1	5/2014	

OTHER PUBLICATIONS

Höfling, S. et al.; Semiconductor Quantum Light Emitters and Sensors; Quantum Sensing and Nanophotonic Devices VII; Proc. of SPIE vol. 7608; pp. 760804-1-760804-9; © 2010 SPIE.

(Continued)

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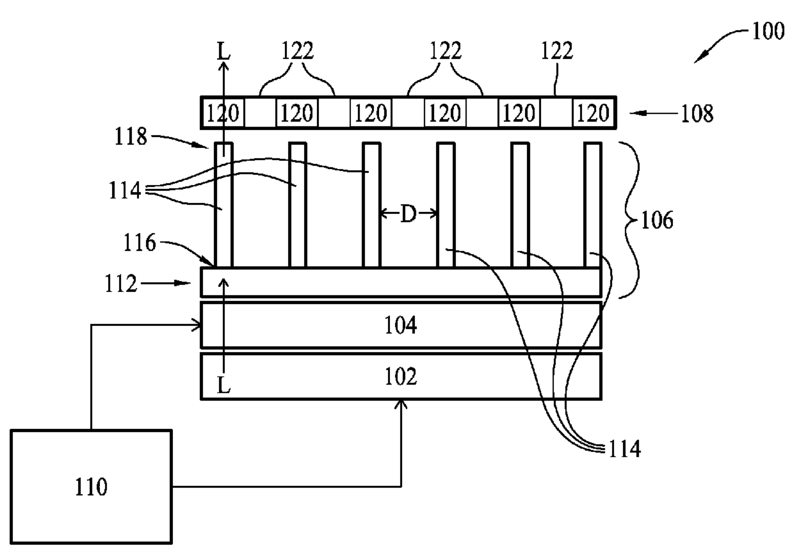
(57) **ABSTRACT**

In one aspect, a display device includes a light source for supplying light energy and a light modulation layer including a plurality of micropillars that each have a fixed end and a free end. An activation layer is configured to activate the micropillars to modulate light energy from the light source passing through the micropillars.

20 Claims, 4 Drawing Sheets

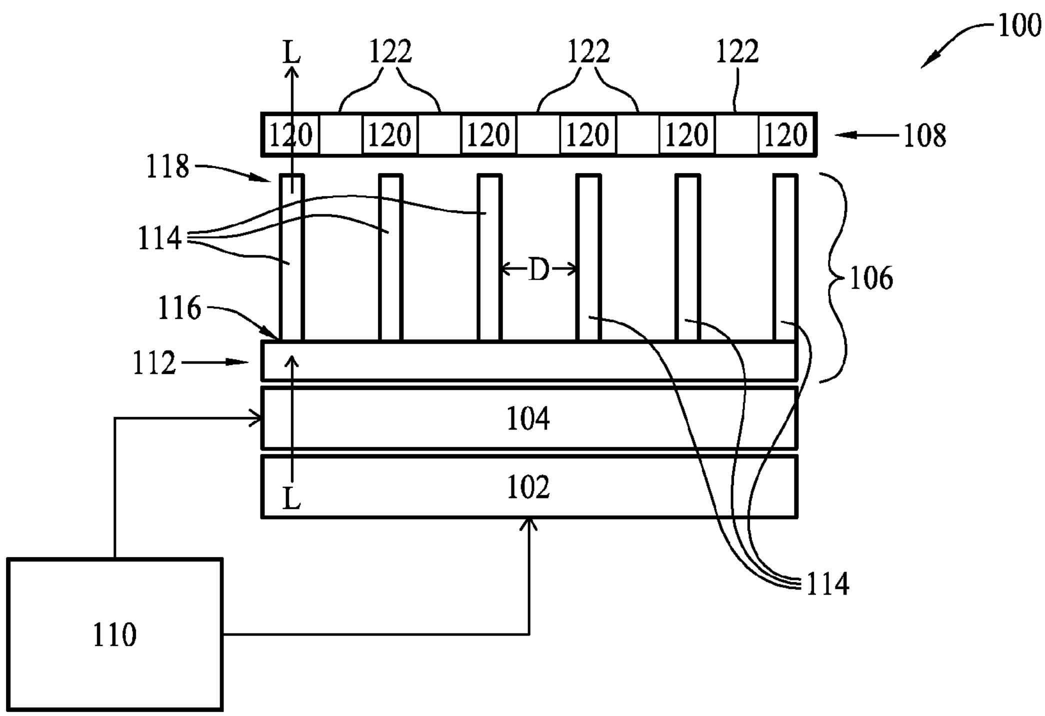


(56) **References Cited**

OTHER PUBLICATIONS

Ghanbari, A. et al.; A Micropillar-based On-chip System for Continuous Force Measurement of *C. elegans*; Journal of Micromechanics and Microengineering; Published Jul. 26, 2012; pp. 1-10; © 2012 IOP Publishing Ltd.
Chan, Yu Fei et al., Electroluminescence from ZnO-Nanofilm/Simicropillar Heterostructure Arrays, Optics Express, vol. 20, No. 22, pp. 24280-24287, 2012.
Microfluids; http://www.imec.bc/ScientificReport/SR2010/2010/1159254.html; 6 pages; 2010; retrieved from internet Jan. 14, 2013.
Hiraoka, M. et al; Integrated Fluidic System for Bio-Molecule Separation; 32nd Annual International Conference of IEEE EMBS; pp. 6514-6517; Buenos Aires, Argentina; Aug. 31-Sep. 4, 2010.
Cheng, D. et al.; A Sensing Device Using Liquid Crystal in a Micropillar Array Supporting Structure; Journal of Microelectromechanical Systems; vol. 18, No. 5; pp. 973-982; Oct. 2009.
EPO Extended Search Report for related application No. 14155649.8-1553 dated Aug. 26, 2014, 7 pp.
EP Extended Search Report for related matter 14-1554683.3-1356 dated Sep. 19, 2014, 10 pp.
Liou, Dar-Sun et al., Axial Particle Displacements in Fluid Slugs After Passing a Simple Serpentiform Microchannel, Nicrofluid Nanofluid, 2009,7:145-148.
Xu, J., et al., Microphone Based on Polyvinylidene Fluoride (PVDF) Micro-Pillars and Patterned Electrodes, Sensors and Actuators, 2009, A153:24-32.
Gallego-Perez, Daniel et al., Versatile Methods for the Fabrication of Polyvinylidene Fluoride Microstructures; Biomed Microdevices, 2010, 12:1009-1017.
Moon, Myoung-Woon et al., Tilted Janus Polymer Pillars; Soft Matter, 2010, vol. 6, pp. 3924-3929.
Menguc, Yigit et al., Gecko-Inspired Controllable Adhesive Structures Applied to Micromanipulation, Adv. Funct. Mater., 22:1246-1254. doi: 10:1002/adfm.201101783, Jan. 19, 2012.
Menguc, Yigit et al., Staying Sticky: Contact Self-Cleaning of Gecko-Inspired Fibrillar Adhesives, 2012, available at http://people.seas.harvard.edu/~ymenguc/research.html; last visited Feb. 25, 2013.
Rivas, Juan (2004). Radio Frequency dc-dc Power Conversion, (Doctorate thesis). Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, Sep. 2006.
European Search Report issued in European Application No. 14156154.8 on Aug. 18, 2014, 9 pages.
Bright, V.M., et al., "Prototype Microrobots for Micro Positioning in a Manufacturing Process and Micro Unmanned Vehicles," Micro Electro Mechanical Systems, 1999. MEMS '99. Twelfth IEEE International Conference, Jan. 17-21, 1999, pp. 570-575.
Byungkyu, Kim et al., "A Ciliary Based 8-Legged Walking Micro Robot Using Cast IPMC Actuators," Proceedings / 2003 IEEE International Conference on Robotics and Automation, Sep. 14-19, 2003, pp. 2940-2945.
Liwei, Shi et al., "A Novel Soft Biometic Microrobot with Two Motion Attitudes," Sensors, vol. 12, No. 12, Dec. 6, 2012, pp. 16732-16758.

* cited by examiner


100
L
122
122
122
120
120
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120
108
118
114
D
106
116
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104
102
L
114
110

FIG. 1

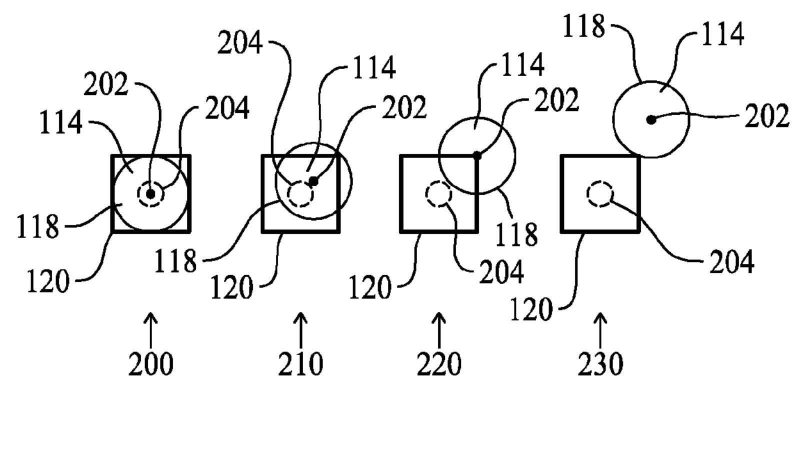

202
114
204
118
120
200
204
114
202
118
120
210
114
202
118
120
204
220
118
114
202
120
204
230

FIG. 2

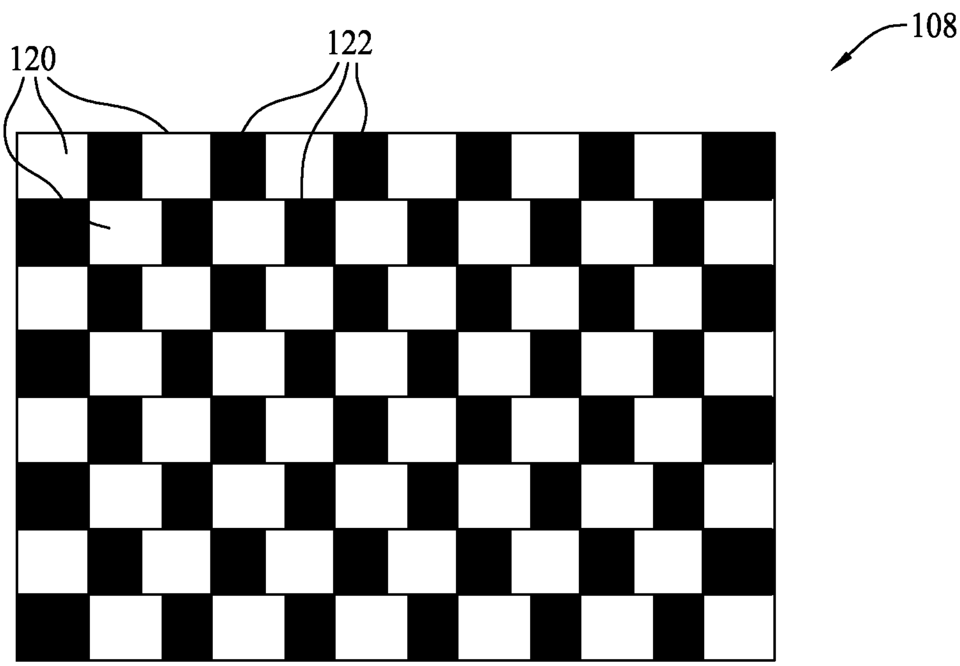


FIG. 3

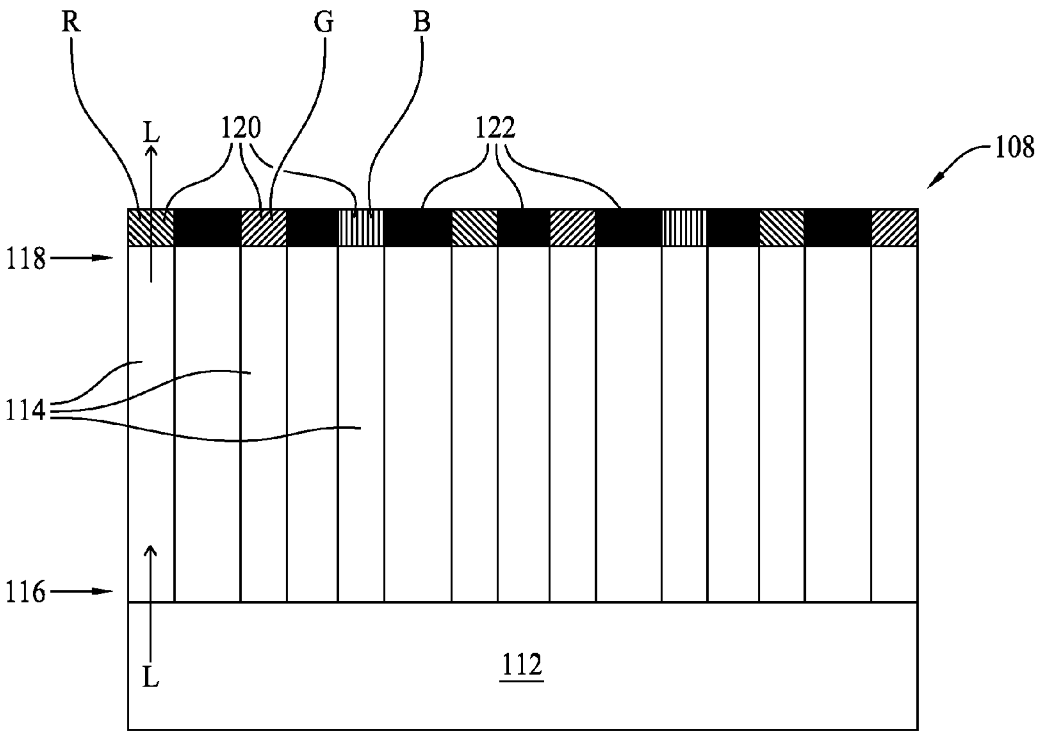
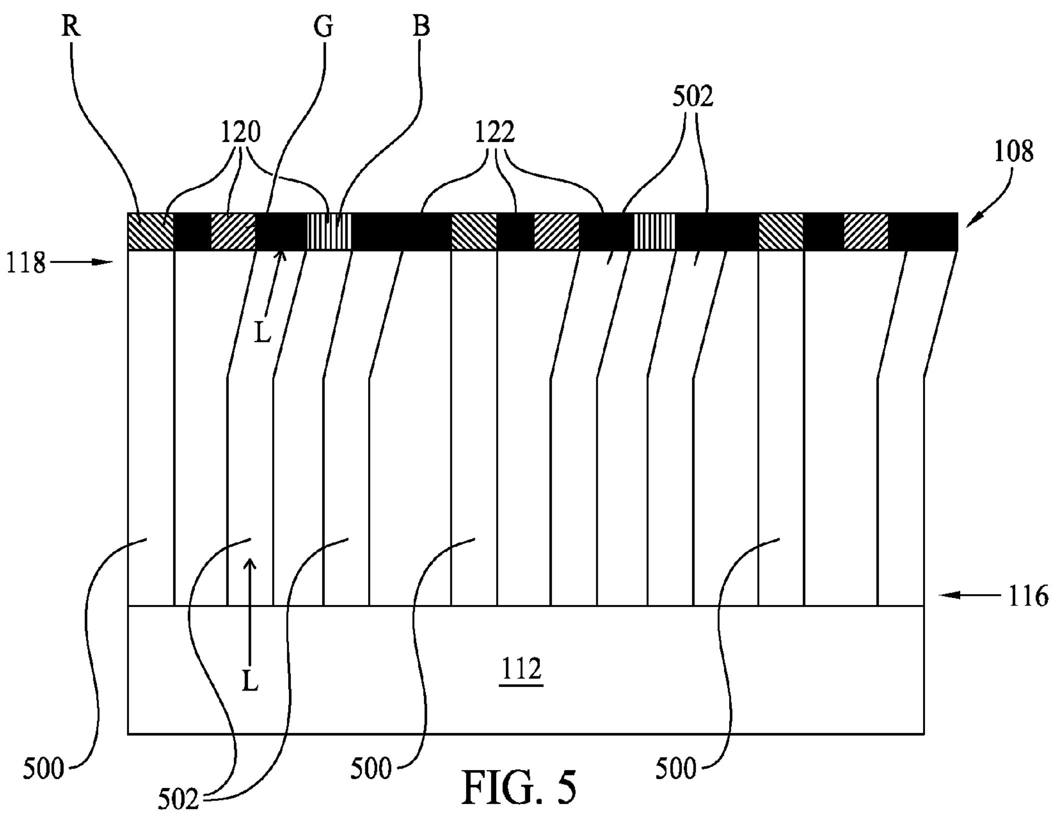

R
G
B
L
120
122
108
118
114
116
L
112

FIG. 4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G
B
502
120
122
108
118
L
116
L
112
500
502
500
500

FIG. 5

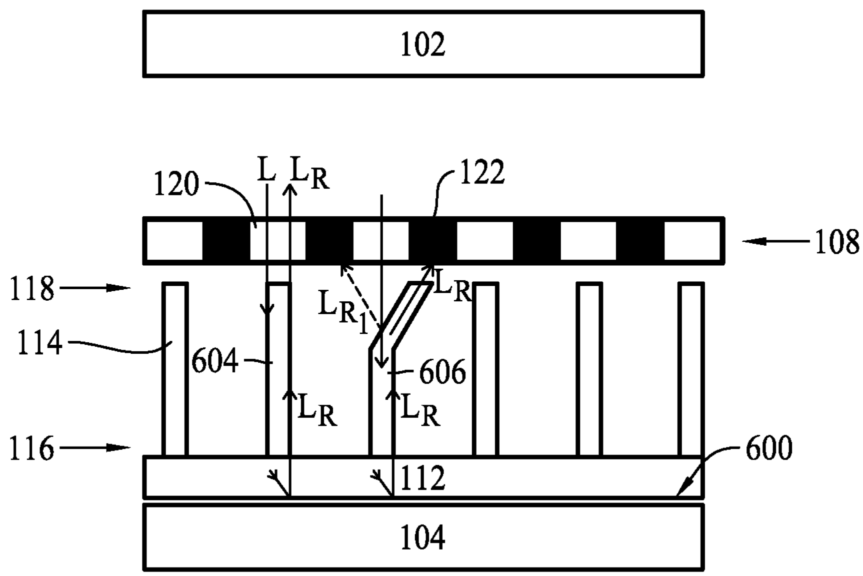

FIG. 6

DISPLAY DEVICE USING MICROPILLARS AND METHOD THEREFOR

FIELD

The field of the disclosure relates generally to display devices. More particularly, the field of the disclosure relates to display devices using micropillars for light modulation.

BACKGROUND

Electronic displays are used with many devices, such as mobile phones, personal computers, televisions and the like. Such displays are used to display information to a user, or other person viewing the display. One type of display technology is known as a liquid crystal display (LCD), and has become increasingly popular due to its relatively thin size, light weight, low power consumption and low electromagnetic radiation compared to prior cathode ray tube displays.

Typically, LCD displays are formed as an assembly including a liquid crystal layer disposed between a thin film transistor (TFT) substrate and a filter layer. When an electric field is applied between a pixel electrode on the TFT substrate and a counter electrode on the filter, an orientation of affected liquid crystal molecules are modified to alter the transmittance of light through the display. By altering the transmittance of the light, the image on the display can be controlled. However, LCD devices require polarized plates to be used, such that unpolarized light is converted to polarized light before being output by the LCD display. The conversion of polarized light to unpolarized light may reduce the efficiency (i.e., the brightness) of the display to 50 percent or less of the brightness of the unpolarized light. As such, additional power consumption is necessary to increase the brightness of such displays, which may reduce the operational life of portable, or battery powered, displays.

Further, LCD displays may be affected by "ghosting" or after-image." Ghosting refers to when a previous image is undesirably retained on the screen of an LCD display when the screen is switched from one image to the next image, due to a slow switching speed of the liquid crystal material in the display.

Although attempts have been made to increase efficiency and reduce ghosting in LCD displays, a need exists for a display that is energy efficient and substantially eliminates the possibility of ghosting.

BRIEF DESCRIPTION

In one aspect, a display device includes a light source for supplying light energy and a light modulation layer including a plurality of micropillars that each have a fixed end and a free end. An activation layer is configured to activate the micropillars to modulate light energy from the light source passing through the micropillars.

In another aspect, an electronic display system includes a light source for supplying light energy and a light modulation layer that includes a plurality of micropillars each having a fixed end and a free end. Each micropillar corresponds to a pixel of an array of pixels. An activation layer is configured to activate the micropillars to modulate light energy from the light source passing through the micropillars. A controller is in communication with the activation layer. The controller is configured to selectively activate each of the micropillars individually.

In yet another aspect, a method of modulating a light source includes transmitting light from a light source to a light modulation layer including a plurality of micropillars each having a fixed end and a free end. The emitted light is received at the fixed ends of the micropillars and emitted from the free ends of the micropillars. At least one of the micropillars is activated to cause a free end of the activated micropillar to be out of alignment with the fixed end of the activated micropillar to modulate the light emitted from the activated micropillar.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic illustration of an implementation of a display system.

FIG. **2** is a plan view of a micropillar in various degrees of activation.

FIG. **3** is a plan view of an implementation of a filter layer.

FIG. **4** is a schematic illustration of display system showing all micropillars in a nonactivated state.

FIG. **5** is a schematic illustration of the display system shown in FIG. **5** having some activated micropillars.

FIG. **6** is a schematic illustration of another implementation of a display system.

DETAILED DESCRIPTION

Referring now to the drawings, and in particular FIG. **1**, an electronic display system is shown generally at **100**. In the exemplary implementation, the display system **100** includes a light source **102**, an activation layer **104**, a light modulation layer **106** and a filter layer **108**. In some implementations, a controller **110** is in communication with one or more of the light source **102** and the activation layer **104**.

The light source **102** is a source that emits electromagnetic radiation in one or more wavelengths. For example, light source **102** may include one or more of a light emitting diode (LED), organic LED, incandescent bulb, fluorescent bulb, neon bulb, ambient light, the sun or any other electronic or chemical device capable of emitting electromagnetic radiation. In some implementations, the light source emits white light, a single color (wavelength of light) of light, a combination of two or more colors of light, ultraviolet light, infrared light or the like. The light source may also emit any combinations of such light. The light source may emit light directionally or omnidirectionally. In the exemplary implementation, when light source **102** emits light L towards filter layer **108**, activation layer **104** is located downstream of light source **102**, light modulation layer **106** is located downstream of activation layer **104**, and filter layer **108** is located downstream of light modulation layer **106**.

The light modulation layer **106** includes a base portion **112** and a plurality of micropillars **114**. Each of the micropillars includes a fixed end **116** and a free end **118**. The fixed ends **116** are coupled to, or formed integrally with, the base portion **112**. The micropillars **114** are substantially transparent, such that light emitted from light source **102** enters the fixed ends **116** and exits the free ends **118** without the intensity of the light being substantially reduced. In one implementation, the micropillars **114** are fabricated of a piezo-electric material, such as lead zirconate titanate (PZT). However, other suitable materials may be used that allow the light modulation layer to function as described herein such as, but not limited to, a shape memory alloy. The light modulation layer **106** may include a plurality of micropillars **114** arranged in an array, such as a rectangular grid pattern having perpendicular rows and columns. In such embodiments, the plurality of micropillars **114** may each be spaced apart by a distance D. The spacing between adjacent ones of the micropillars **114** may be the same between all of the micropillars **114**, or may vary depending upon the desired application.

The activation layer **104** is configured to selectively activate individual ones of the micropillars **114**, for example by transmitting an electrical energy thereto. For example, the application of electrical energy to piezoelectric material or the application and/or removal of heat to a shape memory alloy material can bend micropillars **114**. In one implementation, the activation layer is a thin film transistor (TFT) layer, including a plurality of transistors corresponding to respective ones of the micropillars **114**. One of ordinary skill will appreciate that TFT layers are commonly used in other electronic displays, such as LCD type displays. The details of such activation layers are not further discussed herein.

In the implementation illustrated in FIG. **1**, the display system **100** also includes a filter layer **108**. The filter layer **108** includes a plurality of semi-transparent areas **120** and a plurality of substantially opaque areas **122**. As best shown in FIG. **3**, the semi-transparent areas **120** and substantially opaque areas **122** may be arranged in an array, or grid, as illustrated. One or more of the semi-transparent areas **120** and substantially opaque areas **122** may be used as a pixel of a display. In some embodiments, each of the semi-transparent areas **120** and substantially opaque areas **122** has an individual one of the micropillars **114** associated therewith. However, in some implementations, a single micropillar **114**, or pixel, may be associated with two or more of the semi-transparent areas **120** and substantially opaque areas **122**. In some embodiments, the filter layer **108** may be covered with a protective film or other layer (not shown).

Referring now to FIG. **2**, plan views of a micropillar **114** are illustrated in four different states of activation. In the first state **200**, the micropillar **114** is in a neutral, or deactivated, state. As such, in the first state **200**, the activation layer **104** has not transmitted sufficient activating energy to the micropillar **114** to fully or partially activate the micropillar **114**. In this state, the free end **118** of micropillar **114** is substantially aligned with the semi-transparent area **120**. For example, the axial center **202** of the free end **118** of the micropillar **114** is aligned with the center **204** of the semi-transparent area **120**. In the neutral state **200**, substantially all of the light entering the fixed end **116** of the micropillar **114** is transmitted through the micropillar **114** and exits the free end **118** and then is transmitted through the semi-transparent area **120**, thus creating a "bright spot," "bright pixel" or area of intense light.

In partially activated state **210**, the activation layer **104** has transmitted a sufficient amount of activation energy to the micropillar **114** to cause partial activation of the micropillar **114**. As such, in partially activated state **210**, the free end **118** has bent, or flexed, such that the axial center **202** of the free end **118** is not aligned with the center **204** of the semi-transparent area **120**. As such, only a portion of the light exiting the free end **118** of the micropillar **114** is transmitted through the semi-transparent area **120** (i.e., light from the portion of the free end **118** within the sides of the semi-transparent area **120**). Light transmitted from the free end **118** outside of the semi-transparent area is not transmitted through the semi-transparent area **120**, thus modulating (i.e., reducing) the intensity of the light emitted from the semi-transparent area **120**. Similarly, at partially activated state **220**, the activation layer **104** has transmitted a sufficient amount of activation energy to the micropillar **114** to cause further activation of the micropillar **114** as compared to state **210**. Accordingly, a smaller amount of light is transmitted from the free end **118** through the semi-transparent area **120**, further reducing the intensity of the light. In these states **210**, **220**, a "dim spot," "dim pixel" or area of reduced light intensity (as compared to the bright pixels) is created.

Fully activated state is represented generally at **230**. In the fully activated state, the activation layer **104** has transmitted sufficient energy to bend the free end **118** fully outside of (e.g., fully out of alignment with) the semi-transparent area **120**. As such, none of the light exiting the free end **118** of the micropillar **114** in the fully activated state is transmitted through the semi-transparent area **120**. Thus, the fully activated state **230** creates a "dark spot," "black pixel" or an area lacking light transmission from a micropillar **114**.

In some embodiments, the micropillar **114** is configured such that when activated by activation layer **104**, the free end **118** of the activated micropillar **114** will partially or fully align with a substantially opaque area **122** (FIG. **3**). As such, the light exiting the free end **118** is blocked by the substantially opaque area. In other embodiments, in the neutral state, the free ends **118** of the micropillars **114** may be aligned with the substantially opaque areas **122**, and become partially or fully aligned with the semi-transparent areas **120** upon activation.

Reference is now made to FIGS. **4** and **5**. In the implementation illustrated in FIG. **4**, each of the semi-transparent areas **120** may be a different color. For example, in one implementation the semi-transparent areas **120** alternate as red areas R, green areas G and blue areas B. However, any colors may be used that allow the system to function as described herein, such as Cyan, Magenta, Yellow and Black, or the like. As such, the system **100** may function as a full color display system. In FIG. **4**, each of the micropillars **114** are illustrated in the deactivated state (state **200** shown in FIG. **2**). As such, light L enters the fixed end **116** of the micropillars **114** and exits through all of the semi-transparent areas **120**, thus making the display appear "white." However, in the exemplary implementation illustrated in FIG. **5**, the system **100** has been activated such that only red light is transmitted from the filter layer **108**. For example, in this implementation, the micropillars **500** remain in the deactivated state **200**, such that light is transmitted through red areas R. However, micropillars **502** are shown in the fully activated state **230**, such that light L is blocked by substantially opaque areas **122** after exiting free ends **118**. As such, the only light exiting the filter layer **108** is red light. It will be appreciated that the micropillars **114** may be activated in any manner so as to display other colors of light. In some embodiments, the micropillars may be controlled (i.e., by way of controller **110**) to sequentially activate and deactivate so as to create alternating colors, for example for moving picture displays, such as televisions, computers, or the like.

In another implementation, as illustrated in FIG. **6**, the system **100** is configured such that the light source **102** is located above the filter layer **108**. In this implementation, a reflective layer **600** is located between the activation layer **104** and the fixed ends **116** of the micropillars **114**. In one exemplary implementation, the light source **102** is ambient light. In this implementation, the light source **102** emits light toward the filter layer **108**, and then toward the micropillars **114**. In this implementation, when the micropillars **114** are in the deactivated state, such as micropillar **604**, light L enters the free end of the micropillar **604**, travels through the micropillar **604** and then reflects off of the reflective surface **600**. The reflected light L_R travels back through the micropillar **604** and is emitted through the semi-transparent area **120**, thus creating a "light spot" (i.e., a light pixel). However, to modulate the light, a micropillar **114**, such as micropillar **606** is activated as discussed above. The micropillar **606** is thus activated such that its free end **118** is not aligned with the semi-transparent area **120**. In the implementation shown, the free end **18** of micropillar **606** is aligned with the substantially opaque area **122**. As such, light L transmitted through the semi-transparent area **120** strikes the side of the micropillar **606**, and may be reflected away as light L_{R1}. The light L_{R1} thus does not get reflected and exit back through the semi-transparent area **120**. Any light L that may enter the micropillar **606** through the side thereof, will be reflected from reflective surface **600** and transmitted back through the micropillar **606** as light L_R. However, because micropillar **606** has a free end that is aligned with the substantially opaque area **122**, the light L_R is blocked by the substantially opaque area **122**, thus creating a "dark spot" (i.e., a dark pixel). As such, by selectively activating the micropillars **114**, a plurality of light and dark pixels can be created, to display an image. In some embodiments, sequential activation of the micropillars **114** can be used to create changing images, as discussed above.

In some embodiments, one or more of the components of the display system **100**, such as the light source **102**, activation layer **104**, light modulation layer **106** and filter layer **108** are configured to be flexible such that the display system may be flexed, or bent and may be resiliently deformable such that after being bent to a deformed state, the display system **100** will return to a previously undeformed state.

As used herein, the term controller may refer to an electronic controller, which may include a computer processor or processing device (not shown). The processor is generally any piece of hardware that is capable of processing information such as, for example, data, computer-readable program code, instructions or the like (generally "computer programs," e.g., software, firmware, etc.), and/or other suitable electronic information. For example, the processor may be configured to execute computer programs or commands, which may be stored onboard the processor or otherwise stored in an associated memory (not shown). In yet another example, the processor may be embodied as or otherwise include one or more application-specific integrated circuits (ASICs), field-programmable gate arrays (FPGAs) or the like. Thus, although the processor may be capable of executing a computer program to perform one or more functions, the processor of various examples may be capable of performing one or more functions without the aid of a computer program. As used herein, electronic or computer memory is generally any piece of hardware that is capable of storing information such as data, computer programs and/or other suitable information either on a temporary basis or a permanent basis. In one example, the memory may be configured to store various information in one or more databases. The memory may include volatile and/or non-volatile memory, and may be fixed or removable. Examples of suitable memory include random access memory (RAM), read-only memory (ROM), a hard drive, a flash memory, a thumb drive, a removable computer diskette, an optical disk, a magnetic tape or some combination of the above. Optical disks may include compact disk read-only-memory (CD-ROM), compact disk read/write memory (CD-R/W), digital video disk memory (DVD), or the like. In various instances, the memory may be referred to as a computer-readable storage medium which, as a non-transitory device capable of storing information, may be distinguishable from computer-readable transmission media such as electronic transitory signals capable of carrying information from one location to another. Computer-readable media, as described herein, may generally refer to a computer-readable storage medium or computer-readable transmission medium.

This written description uses examples to disclose the implementations, including the best mode, and also to enable any person skilled in the art to practice the implementations, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the disclosure is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A display device comprising:
a light source for supplying light energy;
a light modulation layer including a plurality of micropillars each having a fixed end and a free end;
an activation layer configured to activate the micropillars such that light energy from the light source passing through the micropillars is modulated, and such that the light energy is emitted from the free end of the micropillars in different directions based on an activation state of the micropillars.

2. The display device according to claim **1**, wherein the activation layer is configured to activate the micropillars by providing a voltage to the micropillars.

3. The display device according to claim **1** further comprising a filter layer including a plurality of opaque areas and a plurality of substantially transparent areas, wherein the light modulation layer is disposed between the filter layer and the activation layer.

4. The display device according to claim **3**, wherein at least some of the substantially transparent areas are colored.

5. The display device according to claim **4**, wherein the substantially transparent areas include at least one green area, at least one red area, and at least one blue area.

6. The display device according to claim **3**, wherein each of the micropillars have a neutral position in which the free end is aligned with one of the substantially transparent areas and a bent position in which the free end is aligned with one of the opaque areas to modulate the light energy.

7. The display device according to claim **1**, wherein the activation layer comprises a thin film transistor.

8. The display device according to claim **1**, wherein the activation layer is located downstream of the light source, the light modulation layer is located downstream of the activation layer, and the filter layer is located downstream of the light modulation layer.

9. The display device according to claim **1**, wherein the micropillars are configured to bend when activated.

10. An electronic display system, comprising:
a light source for supplying light energy;
a light modulation layer including a plurality of micropillars each having a fixed end and a free end, each micropillar corresponding to a pixel of an array of pixels;
an activation layer configured to activate the micropillars such that light energy from the light source passing through the micropillars is modulated, and such that the light energy is emitted from the free end of the micropillars in different directions based on an activation state of the micropillars, and
a controller in communication with the activation layer, the controller configured to selectively activate each of the micropillars individually.

11. The display system according to claim **10**, further comprising a color filter layer, the color filter layer including an array of semi-transparent colored areas and substantially opaque areas, at least one semi-transparent colored area and at least one substantially opaque area associated with each of the micropillars.

12. The display system according to claim **11**, further comprising a reflective layer between the micropillars and the activation layer.

13. The display system according to claim **11**, wherein each of the micropillars is associated with at least three different colored semi-transparent colored areas.

14. The display system according to claim **10**, wherein the free end of the micropillars is configured to bend upon activation by the activation layer.

15. A method of modulating a light source, comprising:

transmitting light from the light source through a light modulation layer including a plurality of micropillars each having a fixed end and a free end;

receiving the transmitted light at the fixed ends of the micropillars and emitting the light from the free ends of the micropillars; and

activating at least one of the micropillars to cause a free end of the activated micropillar to be out of alignment with the fixed end of the activated micropillar to modulate the light emitted from the activated micropillar to generate an image on a display.

16. The method according to claim **15**, wherein activating at least micropillar causes the free end of the activated micropillar to be aligned with a substantially opaque area of a filter layer located downstream of the micropillars.

17. The method according to claim **16**, further comprising transmitting light from the free ends of non-activated ones of the micropillars to a substantially transparent area of the filter layer.

18. The method according to claim **16**, wherein activating the micropillars includes using a thin film transistor to activate the micropillars.

19. The method according to claim **17**, further comprising transmitting light from the free ends of non-activated ones of the micropillars to at least one colored substantially transparent area of the filter layer.

20. The method according to claim **16** further comprising sequentially activating and deactivating a plurality of the micropillars to generate a moving image.

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